U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject:	Action: Review and Concurrence, Equivalent Level of Safety Finding for the Embraer Model ERJ-170 FAA Project Number TC00561B-T	Date:	July 7, 2003
		Reg Ref:	§§ 25.901, 25.1305, 25.1321, 25.1549
From:	Manager, TSS Propulsion/Mechanical Systems Branch, ANM-112	Reply to Attn of:	Lanny Pinkstaff ANM-112
To:	Manager, International Branch, ANM-116	ELOS Memo #:	TC00561B-T-HPR-14

Background

The digital-only presentation of high-pressure rotor speed (N2) may unacceptably limit the flight crew's ability to properly monitor and operate the engines. The primary engine displays on turbine powered transport aircraft have traditionally displayed the engine rotor speed required by FAR 25.1305(c)(3) in an analog-only or an analog and digital format. An increasing demand to conserve primary display space has led to digital-only primary displays for those rotor speeds not normally used for power setting. This situation may result in a small cluttered, low-resolution primary display.

It is generally accepted that digital-only displays are often less effective than conventional analog displays at providing the crew with: discernible indication of the parameter during a rapid transient; and quick intuitive indication of the parameters approximate level, direction and rate of change, proximity to limits and relationship to other parameters on the same engine or the same parameter on other engines. This is why FAA AC 20-88A, paragraph 4(c), states that: "digital indicators are most valuable when integrated with an analog display".

Applicable regulation(s)

§§ 25.1305, 25.1321, 25.1549

Regulation(s) requiring an ELOS

§ 25.1305(c)(3)

Description of compensating design features or alternative standards that allow the granting of the ELOS (including design changes, limitations or equipment need for equivalency)

- N2 is not used in the thrust setting process. The primary thrust setting parameter is fan speed (N1). The gas generator high pressure rotor speed (N2) will vary as required by closed loop control to maintain the selected fan speed.
- Engine starting and fuel-on selection is automatic. Fuel-on selection during engine starts is automatically commanded by the FADEC, ensuring consistent engine start procedures. All engine control parameters that are relevant for engine starting such as fuel flow rate, turbine temperature and compressor variable geometry/bleed are set and limited as required by the FADEC. During the engine start procedure the crew will monitor the high pressure rotor speed to detect engine abnormalities during the start sequence.

- Automatic FADEC monitoring of N2 is provided to prevent limit exceedance. Continuous monitoring of N2 by the FADEC ensures a prompt fuel flow cutback if the FADEC software governor limit is reached. If, for any reason, the N2 speed is allowed to reach or exceed the redline limit, the N2 digital indication for the affected engine will be boxed red, the digits will be red and the red box will flash, thus providing active limit exceedance information to the crew.
- In addition to the N2 speed limit protection provided by the FADEC software, the FADEC incorporates an independent N2 overspeed protection function. When N2 exceeds the overspeed N2 threshold the fuel is shut-off. The FADEC will detect the flameout and turn on ignition. When N2 speed falls below the overspeed threshold, the overspeed solenoid is de-energized and fuel is readmitted to the engine. The overspeed system latches fuel off if three or more overspeed conditions are detected within 30 seconds.
- Cross comparison of N2 values between the two engines and verification that N2 is in the expected range can effectively be performed by the crew with digital-only N2 indication. The crew usually performs these tasks as routine actions, when cockpit workload permits.

Explanation of how design features or alternative standards provide an equivalent level of safety to the level of safety intended by the regulation

Section 25.1305(c)(3) is intended to ensure engine limits are not exceeded and to ensure that engine abnormalities that could lead to engine failure or other undesirable engine behaviors are identified and addressed in a timely manner. At the time this rule was promulgated, the available technology primarily relied on flight crew awareness and direct action to respond to engine abnormalities. Analog instrumentation was required to provide appropriate crew awareness, as noted in the Background section of this Memo. Since that time, the development of FADEC systems has relieved the flight crew of much of the burden of monitoring engine indications, particularly for secondary engine parameters not directly used for power setting.

The compensating design features noted above, supplementated by testing and analysis, provide sufficient assurance that the intent of 25.1305(c)(3) will be satisfied for the ERJ-170. The testing and analysis is designed to confirm that the visibility, relative location, criticality, and functionality of this display does not require any of the explicit or implicit benefits of a traditional analog display. The availability of the display has been shown to be commensurate with its' criticality. Given the noted compensating design features, the proposed ERJ-170 digital-only N2 display will meet the intent of all applicable FARs.

FAA approval and documentation of the ELOS

The FAA has approved the aforementioned Equivalent Level of Safety Finding as documented in Centro Técnico Aeroespacial Ficha de Controle Assuntos Relevantes HPR-14. This memorandum provides standardized documentation of the ELOS that is non-proprietary and can be made available to the public. The Transport Directorate has assigned a unique ELOS Memorandum number (see front page) to facilitate archiving and retrieval of this ELOS. This ELOS Memorandum number should be listed in the Type Certificate Data Sheet under the Certification Basis section. [E.g. Equivalent Safety Findings have been made for the following regulation(s):

§ 25.1305(c)(3) Digital Only Display of Turbine Engine High/Intermediate Pressure Rotor Speed (N2) (documented in TAD ELOS Memo TC00561B-T-HPR-14)]

original signed by Neil D. Schalekamp — *9/16/03*

Manager, TSS, Propulsion/Mechanical Systems Branch, ANM-112 — Date

ELOS Originated by: Standards Staff, Propulsion Branch	Project Engineer Lanny Pinkstaff	Routing Symbol ANM-112